

42P12965C

PATENT

UNITED STATES PATENT APPLICATION  
FOR

RECEIVER CODEC SUPER CONSTELLATION GENERATOR

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## RECEIVER CODEC SUPER SET CONSTELLATION GENERATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Provisional U.S. Patent Application Serial No. 60/140,075 filed June 24, 1999 and Provisional U.S. Patent Application Serial No. (UNASSIGNED, DOCKET NO CRUS-0156) filed on June 26, 1999, both of which are incorporated herein by reference.

The subject matter of the present invention is related to that in the following co-pending U.S. Patent Applications:

Attorney Docket No. 0931 entitled "Digital Impairment Learning Sequence";

Attorney Docket No. 0932 entitled "Pad Detection";

Attorney Docket No. 0933 entitled "Inter-Modulation Distortion Detection"; and

Attorney Docket No. 0934 entitled "Constellation Generation and Re-evaluation" filed May 18, 2000, which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to an improved technique for generating a super set pulse amplitude modulated (PAM) constellation for a computer modem. In particular, the present invention is directed to accommodating Robbed-Bit Signaling (RBS), programmed attenuation (PAD), and Inter-Modulation Distortion (IMD) during a Digital Impairment Sequence (DIL) conducted with V.90 modems or the like.

BACKGROUND OF THE INVENTION

The V.90 modem is also known as the 56K modem, which, due to power limitations imposed by the FCC is presently limited to 53Kbits/second transmission rate. Figure 4 is a simplified block diagram illustrating how a V.90 modem 530 may be connected to a server 510 through a codec 520. V.90 modem 530 is an analog modem communicating with a telephone company (telco) codec (coder/decoder) 520 through a local dial-up line or local loop 540.

As may be appreciated by one of ordinary skill in the art, such a local loop 540 may contain analog impairments characterized as "loop loss". V.90 modem 530 may be provided

with an equalizer to offset some of this loop loss. Data transmitted from V.90 modem 530 to codec 520 may be in one of a number of formats depending upon the type of codec.

For example, a so-called  $\mu$ -law codec may receive data in a 13-bit format (as illustrated in Figure 4). A so-called A-law codec may receive data in a 12-bit format. Other, so-called "non-conforming" codecs may receive data in yet other formats. Regardless of which format the data is received in, codec 520 converts data received from V.90 modem 530 into digital form (typically 8 bits) for transmission over a telco digital trunk line 550 to server 510.

Digital trunk line 550 may itself contain so-called "digital" impairments, including robbed bit signalling (RBS), digital pad (PAD) and inter-modulation distortion (IMD). Most of these digital impairments are due to design considerations implemented in the telco digital network when it was largely used as a voice-only network. However, such impairments present problems in transmitting digital data over such a network.

The V.90 standard adds to and inherited advantageous features of pre-V.90 56K modems (e.g., X2 modem and Kflex modem). One important feature of the V.90 modem is performance

optimization. Using Digital Impairment Learning sequence (DIL) data, the client modem is capable of generating optimal constellations to achieve best throughput for given conditions.

5 V.90 constellations rely closely on DIL data points. Thus, accuracy of DIL data is one key for accurate constellation generation. One big problem of the prior art is how to obtain highly accurate and optimal DIL data points. V.90 modem 530 must receive a training signal (the Digital Impairment Learning signal, or DIL) and be able to distinguish analog impairments from digital impairments ("de-noising" data) in order to properly  
10 characterize the data channel and generate accurate and optimal data constellations.

#### SUMMARY OF THE INVENTION

15 In the present invention, several techniques are proposed to de-noise DIL data and to achieve accurate DIL data, including a linear-to-Ucode conversion algorithm, PAD/RBS pattern detection, DIL de-noising processing, and a  $\frac{1}{2}$ -RBS de-noising process.

By detecting the non-RBS pattern (e.g., no RBS is present), the DIL data points of the non-RBS slots are averaged to increase

accuracy of the received DIL data. Similarly, using averages of DIL data with the same RBS-pattern slots, more accurate DIL data points are obtained. Accurate DIL points provide a key for optimal data throughput performances of the modem.

5        Received linear DIL data points are equalizer outputs and may be rough and noisy. By the linear-to-Ucode conversion, the DIL rough data may be converted to Ucode indices. The Ucode indicies may be matched to the closest G.711 ( $\mu$ -law or a-law) values. This process serves to de-noise the DIL data.

10        The  $\frac{1}{2}$ -RBS slot refers to D4 channel bank CODECs specified in AT&T Technical Reference, PUB 43801, November 1982., that output close to mid-values of its normal outputs in the RBS slots. In here the codec transfer characteristic changes to span the entire dynamic range using 7 bits during RBS slot. Present invention  
15 matches for the ideal values specified for this type CODEC in the  $\frac{1}{2}$ -RBS slot. This is noted as  $\frac{1}{2}$ -RBS de-noising.

The present invention may also detect and eliminate DIL data points which are too noisy and/or non-monotonic. In addition, an upper limit may be set for constellation points to avoid  
20 saturation of the receiver, by applying PAD and IMD correction. Ideal DIL data points may be added for typical 0dB, 3dB and 6dB

PAD to help create optimal constellation tables and thus optimal modem connections. If PAD-detection has failed, the PAD may be set to 0dB and the constellation based on originally received DIL data points.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram illustrating how a non-RBS slot is detected.

Figure 2 is a flowchart illustrating the steps in the DIL de-noising process.

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Figure 3 is a flow chart illustrating the steps in the DIL de-noising process for  $\frac{1}{2}$ -RBS slot.

Figure 4 is a simplified block diagram illustrating how a V.90 modem may be connected to a server through a codec.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 4, server 510 modem transmits a DIL sequence which is made out of PCM (Pulse Code Modulation) codes (numbers ranging from -128 to 127) as specified in the DIL descriptor. Passing digital trunk with digital impairments 550, the DIL sequence becomes modified by digital impairments such as PAD gain, RBS, Codec type. At the output of Codec 520, the received linear values are further impaired in local loop with analog impairments 540 by analog impairments of noise, non-linearity, echo and loop characteristics.

Thus, the received equalizer outputs of client modem 530 corresponds to Codec receive levels corrupted by the non-cancelable impairments. In the present invention, by using the calculated PAD gain, a linear-to-Ucode conversion algorithm and a hard slice-algorithm, noisy receive levels may be correlated to ideal Codec levels. This technique of correlating noisy received DIL levels to ideal DIL levels is referred to as the de-noising process.



RBS DETECTION

RBS (robbed-bit signaling) is a signaling method used by digital networks to transmit data between digital equipment on a telephone network. RBS uses the LSB (least-significant bit) of the same slot in each data frame to send data between components of a telephone system. During the digital connection, this RBS bit may be set to 1, 0, or toggled between 1 and 0. Therefore, the digital network may change one of every six symbols to a different value from the one sent originally. In each data frame, the slot used for RBS is called the RBS slot (otherwise, it is the no-RBS slot).

Comparing to the pre-V.90 standard modem (X2 and Kflex), one of the big advantages of V.90 modem is it is capable of achieving optimal performance based on individual loops. The DIL descriptor asks digital modem 510 to send desired Ucode sequence, which, when received by analog modem 530, are used to create the receiver code super constellations. The so-called DIL points are averages of number of linear equalizer outputs corresponding to the same Ucode in the same slot. The accuracy of the received DIL points is one key for V.90 performance. The received linear values may be matched to the closest decoded linear values, using

the linear-to-PCM-conversion algorithm. For this reason, it may be necessary to first perform RBS detection.

For example, suppose there are two non-RBS symbol slots. For those slots, the two sets of DIL points may be averaged to get more accurate data. If RBS is not present (and that fact can be detected) more accurate constellations may thus be created and V.90 performance is improved. In general, if RBS-pattern slots are detected, the means of these DIL points are more accurate to use. This leads to optimal V.90 modem performance.

RBS detection is disclosed in more detail in Provisional U.S. Patent Application Serial No. 60/140,075 filed June 24, 1999 and copending U.S. Patent Application Attorney Docket No. 0933 entitled "Inter-Modulation Distortion Detection" also claiming priority from Provisional U.S. Patent Application Serial No. 60/140,075.

A similar RBS detection method is described here. In the V.90 modem, a data frame may comprise six slots. Each slot corresponds to one set of DIL points. Figure 1 is a block diagram illustrating how a non-RBS slot is detected. Twenty of the DIL data points (e.g., from 80 to 99) for each slot may be used for RBS detection as illustrated in step 110. These twenty

points are selected as they are considered to be stable and reliable points under most conditions.

The threshold illustrated in Figure 1 for non-RBS detection may be set to 1. Example 1 discussed below illustrates the procedures for RBS-pattern detection. In practice, only a few DIL data points (numbered from 80 to 99) may be used for RBS-pattern identification as illustrated in step 110 of Figure 1.

In step 120, the linear to U-code conversion takes place. The linear to U-code conversion algorithm is described below in connection with Example 1. The system PAD gain may be input in step 120 as a variable in the linear to U-code conversion.

PAD gain may be detected by any one of a number of techniques, including the technique disclosed in Provisional U.S. Patent Application Serial No. 60/140,075 filed June 24, 1999 incorporated herein by reference and in co-pending U.S. Patent Application Attorney Docket No. 0932 entitled "Pad Detection", also claiming priority from Provisional U.S. Patent Application Serial No. 60/140,075. Digital PAD is one kind of digital power loss measured in dB.

There are a limited number of known digital PADs, (e.g., 0dB, 3dB, 3.5 dB, 6dB and 8dB). Once the amount of digital PAD is known, several typical constellation points may be pre-calculated independently of RBS. Then digital loop (PAD information) may be determined, using a matching pursuit method. A similar but different approach is disclosed in proposed in Application Attorney Docket No. 0932 entitled "Pad Detection".

In step 130, the U-code values for the twenty selected levels of the six slots are stored. In step 140, Ucode values for a given index (n) are subtracted from subtracted from Ucode values for an adjacent index (n+1). The resultant set of values  $N_{rbs}$  is checked against a predetermined threshold value, in this case set to one. In step 160, if number of difference values greater than one ( $N_{rbs}$ ) is greater than a decision value (e.g., 8) then a no-RBS decision is made (e.g., this slot has no RBS).

#### DIL DE-NOISING

Figure 2 is a flowchart illustrating the steps in the DIL de-noising process. The values transmitted by the digital modem may be selected from 128 points (e.g., the G.711 points). The

received linear values may comprise noisy G.711 points as illustrated in step 210 of Figure 2.

In step 220 DIL points in the slots with the same RBS pattern are averaged. The improved DIL data is then stored in  
5 step 230.

The digital PAD attenuation is compensated by scaling down the DIL data by pad gain in step 235. The improved DIL data may then be matched to the closest G.711 points (the decoder linear values), by first using the linear-to-Ucode conversion algorithm  
10 (described below) in step 240 to produce Ucode DIL values in step 250. The Ucode DIL values in step 250 are then matched to their closest standard G.711 points. Finally, de-noised DIL data is obtained in step 260 by converting the standard G.711 Ucode values back to linear values, after being scaled up by the pad gain in  
15 step 255.

Since the linear to Ucode conversion process converts linear values to their nearest corresponding Ucode value, the Ucode to linear conversion in step 260 does not simply yield back the noisy linear data of steps 210 or 230. When converted back to linear  
20 values, the Ucode data of step 250 is converted back to a standard linear value, not a noisy linear value.

By this algorithm, the DIL linear equalizer outputs are converted to PCM Ucode indices. They then may be matched to the closed G.711 ( $\mu$ -law or a-law) values. This is a de-noising processing, which increases the accuracy of the DIL data. The mathematical formula for the linear-to-Ucode conversion (for  $\mu$ -law only) is formulated as follows (It is similar for A-law).

The following formulas illustrate how linear-to-Ucode conversion algorithm works. A linear positive value  $x$  describes the input value. Such linear values represent signal level (voltage) in scaled units from 0 to 32124 (7D7C hex) as determined by ITU standard G.711. The output of the algorithm is described by U-code  $y$ . For the  $\mu$ -law case the conversion is calculated as follows.

First, set  $x = \min(x, 32124)$ . That is to say, let  $x$  be the minimum value of either  $x$  or 32124. If  $x$  is greater than 32124, redefine  $x$  to equal 32124. Next, calculate  $f$  and the smallest  $e$  to satisfy the equation  $2^e \cdot f = x + 132$ , where  $0 \leq f < 32$ . Finally, calculate  $y$  as  $y = 16 \cdot e + \lfloor f \rfloor - 64$ , where  $\lfloor f \rfloor$  is the integer part of  $f$ . The notation  $\lfloor f \rfloor$  indicates "floor" or the absolute integer value of  $f$  (any decimal portion is truncated).

For the A-law case, a similar algorithm is used. First, set  $x = x + 256$  if  $x$  is less than 256. Next, we set  $x = \min(x, 32256)$ . That is to say, let  $x$  be the minimum value of either  $x$  or 32256. If  $x$  is greater than 32256, redefine  $x$  to equal 32256. Next, calculate  $f$  and the smallest  $e$  to satisfy the equation  $2^e \cdot f = x$ , where  $0 \leq f < 32$ . Finally, calculate  $y$  as  $y = 16 \cdot e + \lfloor f \rfloor - 64$ , where  $\lfloor f \rfloor$  is the integer part of  $f$ . The notation  $\lfloor f \rfloor$  indicates "floor" or the absolute integer value of  $f$  (any decimal portion is truncated).

#### 10 1/2-RBS DIL DATA DE-NOISING

1/2RBS detection is disclosed in more detail in Provisional U.S. Patent Application Serial No. 60/140,075 filed June 24, 1999 incorporated herein by reference and in co-pending U.S. Patent Application Attorney Docket No. 0932 entitled "Pad Detection", also claiming priority from Provisional U.S. Patent Application Serial No. 60/140,075.

Figure 3 illustrates the DIL de-noising process for 1/2-RBS slot. In step 310, 1/2-RBS slot DIL data is received as linear values. Using the calculated PAD gain and the linear to Ucode algorithm of the present invention, the 1/2-RBS DIL linear data is

converted to Ucodes  $U(n)$  in step 320 and stored in step 330. In step 340 the average of the linear values corresponding to the two G.711 points  $X(n)$  and  $Y(n)$  closest to the received linear values. This averaged value becomes the  $\frac{1}{2}$ -RBS slot DIL data in step 350.

5     Eliminating points which are non-monotonic:

Because of the noisy channel, noisy data may be obtained. In a case where a received data point is far away from the idea G.711 points, the received data point may be eliminated. The criterion is comparing the difference of received data and the ideal point  
10     against the quarter of the minimal DIL-segment distance.

IMD correction may be first applied if needed to the de-noised the decode levels. Next, ideal points corresponding to the holes in the DIL sequence are added in case the channel is very clean and the pad and codec are one of the standard ones (0dB,  
15     3dB, 6dB, a-law) so as to increase the data rate possibilities and V.90 modem throughput.

In case of pad-detection failure, the raw decode levels may be used as those in RBS slots and averaged raw decode levels in non-RBS slots for the receive decode levels and pad gain may be



set to 0dB so as not to violate the regulatory transmit power restriction of the server.

Next, the upper constellation point may be limited, based on IMD and based on the PAD to avoid saturation of the receiver. For example, if digital PAD loss is too high (PAD=8dB or above), the constellation points may be limited up to index 112.

Example 1: (Linear to PCM Code Conversion)

This example illustrates how DIL data is processed. The purpose here is to increase the accuracy of received DIL data such that the modem performance may be optimized. The data in Example 1 was generated from actual telephone line conditions in Fremont, California line connecting to the U.S. Robotics™ BBS server.

In Example 1 a pad gain of 323Bh (12859 decimal) was previously determined using the techniques set forth U.S. Provisional Patent Application Serial No. 60/140,075 filed June 24, 1999, previously incorporated herein by reference. Pad gain is first converted to a decimal value, where a pad gain of 7FFF (32767 decimal) is equated to a pad value of 1.0. Thus, pad gain in this instance =  $12859/32767 = 0.3924$ .

Table 1 illustrates DIL Linear Values for each of the six slots DIL0 through DIL5, along with numbered index of the level number. Table 2 illustrates the CODEC U-CODE Indices for the same data.

5       Applying the linear-to-Ucode conversion formulas discussed above, the relationship between Table 2 and Table 3 can be illustrated. For example, in slot DIL0, index 16, a first linear value  $x$  of 144 appears. Multiplying the value by our pad gain of 0.3924, we obtain a padded value of 55.7. For a  $\mu$ -Law  
10       conversion, we first, set  $x = \min(x, 32124)$ . In this instance,  $x$  is much less than 32124, and thus our  $x$  value remains 55.7.

Next, we calculate  $f$  and the smallest  $e$  to satisfy the equation  $2^e \cdot f = x + 132$ , where to  $0 \leq f < 32$ . In this instance, since  $x = 55.7$ , the equation reduces to:

15        $2^e \cdot f = 55.7 + 132$ , where to  $0 \leq f < 32$ , or  
 $2^e \cdot f = 187.72$ , where to  $0 \leq f < 32$ , or  
 $f = 187.72/2^e$ , where  $0 \leq f < 32$ , or  
 $f = 23.46$  and  $e = 3$ .

Finally, we calculate UCODE  $y$  as  $y = 16 \cdot e + \lfloor f \rfloor$ , where  $\lfloor f \rfloor$  is the integer part of  $f$ . Plugging in the  $f$  and  $e$  values calculated above, we yield:

$$y = 16 \cdot e + \lfloor f \rfloor - 64, \text{ or}$$

$$5 \quad y = 16 \cdot 3 + \lfloor 23.46 \rfloor - 64, \text{ or}$$

$$y = 16 \cdot 3 + 23 - 64 = 7$$

The remaining UCODE values in Table 2 are calculated in a similar manner.

# PATENT

DIL0	DIL1	DIL2	DIL3	DIL4	DIL5	INDEX	DIL0	DIL1	DIL2	DIL3	DIL4	DIL5	INDEX
0	0	0	0	0	0	0	1981	1983	1981	1978	1980	1983	64
0	0	0	0	0	0	1	2138	1985	1981	2144	2134	1980	65
0	0	0	0	0	0	2	2215	2223	2222	2227	2215	2220	66
0	0	0	0	0	0	3	2351	2223	2224	2354	2346	2219	67
0	0	0	0	0	0	4	2524	2512	2505	2512	2518	2513	68
0	0	0	0	0	0	5	2683	2520	2514	2674	2675	2511	69
0	0	0	0	0	0	6	2844	2847	2840	2841	2835	2839	70
0	0	0	0	0	0	7	2839	2843	2847	2850	2836	2838	71
0	0	0	0	0	0	8	3010	3014	3004	3008	2996	3007	72
0	0	0	0	0	0	9	3176	3011	3000	3172	3167	3006	73
0	0	0	0	0	0	10	3334	3338	3333	3336	3329	3329	74
0	0	0	0	0	0	11	3508	3341	3315	3496	3497	3328	75
0	0	0	0	0	0	12	3497	3499	3492	3497	3487	3499	76
0	0	0	0	0	0	13	3658	3498	3492	3650	3654	3487	77
0	0	0	0	0	0	14	3821	3825	3819	3824	3809	3816	78
0	0	0	0	0	0	15	3984	3823	3817	3985	3976	3813	79
144	147	143	145	145	142	16	4141	4152	4136	4151	4139	4141	80
0	0	0	0	0	0	17	4469	4144	4134	4462	4462	4134	81
0	0	0	0	0	0	18	4631	4634	4622	4634	4619	4629	82
0	0	0	0	0	0	19	5046	4638	4623	5045	5037	4612	83
205	206	204	207	205	203	20	5053	5055	5046	5054	5036	5041	84
0	0	0	0	0	0	21	5385	5045	5039	5375	5371	5040	85
0	0	0	0	0	0	22	5701	5705	5700	5704	5687	5695	86
0	0	0	0	0	0	23	6029	5710	5697	6034	6018	5699	87
265	265	265	267	266	264	24	6363	6366	6351	6363	6344	6347	88
0	0	0	0	0	0	25	6369	6363	6350	6355	6351	6348	89
0	0	0	0	0	0	26	6684	6692	6674	6687	6671	6675	90
0	0	0	0	0	0	27	7017	6689	6675	7007	6992	6671	91
337	337	336	338	334	332	28	7341	7349	7326	7342	7323	7328	92
0	0	0	0	0	0	29	7661	7339	7325	7661	7644	7316	93
0	0	0	0	0	0	30	7665	7666	7646	7660	7651	7643	94
0	0	0	0	0	0	31	7991	7675	7654	7988	7964	7650	95
417	420	415	421	418	417	32	8313	8316	8276	8306	8274	8301	96
0	0	0	0	0	0	33	8960	8331	8273	8960	8922	8317	97
456	458	456	461	457	455	34	9606	9602	9582	9607	9563	9603	98
0	0	0	0	0	0	35	9936	9605	9570	9923	9884	9608	99
539	539	534	540	541	537	36	10442	10440	10397	10444	10412	10441	100
0	0	0	0	0	0	37	11108	10456	10393	11086	11048	10437	101
578	576	576	578	579	574	38	11746	11734	11717	11748	11722	11761	102
0	0	0	0	0	0	39	12421	11751	11719	12406	12361	11764	103
658	661	656	657	660	657	40	12386	12389	12368	12396	12370	12421	104
0	0	0	0	0	0	41	13061	12390	12361	13050	13020	12395	105
738	739	734	739	741	739	42	13719	13711	13672	13726	13662	13728	106
0	0	0	0	0	0	43	14367	13713	13678	14348	14315	13733	107
779	781	778	784	779	779	44	15006	15004	14967	15021	14975	15036	108
0	0	0	0	0	0	45	15030	15008	14961	15003	14974	15029	109
856	861	857	863	859	861	46	15667	15655	15615	15647	15616	15687	110
0	0	0	0	0	0	47	16315	15661	15628	16291	16267	15676	111
940	940	938	946	940	940	48	16977	16906	16949	17010	16952	16932	112
997	940	934	1004	1003	929	49	18264	16880	16999	18360	18228	16952	113
1088	1085	1085	1084	1087	1081	50	18905	18900	18938	18958	18909	18890	114
1169	1084	1086	1170	1168	1080	51	20250	18870	18936	20260	20180	18906	115
1172	1168	1162	1170	1174	1165	52	21260	21164	21232	21292	21210	21187	116
1253	1166	1167	1250	1247	1164	53	22567	21130	21221	22630	22542	21152	117
1335	1331	1332	1334	1330	1331	54	23847	23733	23839	23956	23864	23815	118
1418	1329	1324	1408	1413	1325	55	23893	23807	23854	23905	23823	23809	119
1411	1410	1408	1414	1410	1405	56	0	0	0	0	0	0	120
1493	1414	1409	1495	1495	1404	57	0	0	0	0	0	0	121
1573	1577	1576	1577	1577	1569	58	0	0	0	0	0	0	122
1656	1571	1572	1655	1651	1571	59	0	0	0	0	0	0	123
1736	1739	1732	1740	1736	1733	60	0	0	0	0	0	0	124
1736	1737	1732	1743	1732	1734	61	0	0	0	0	0	0	125
1819	1819	1812	1815	1816	1814	62	0	0	0	0	0	0	126
1899	1819	1816	1904	1896	1813	63	0	0	0	0	0	0	127

TABLE 1: RECEIVED DIL LINEAR VALUES

## PATENT

DIL0	DIL1	DIL2	DIL3	DIL4	DIL5	INDEX	DIL0	DIL1	DIL2	DIL3	DIL4	DIL5	INDEX
0	0	0	0	0	0	0	44	44	44	44	44	44	64
0	0	0	0	0	0	1	46	44	44	46	46	44	65
0	0	0	0	0	0	2	47	47	47	47	47	47	66
0	0	0	0	0	0	3	48	47	47	48	48	47	67
0	0	0	0	0	0	4	49	49	49	49	49	49	68
0	0	0	0	0	0	5	50	49	49	50	50	49	69
0	0	0	0	0	0	6	51	51	51	51	51	51	70
0	0	0	0	0	0	7	51	51	51	51	51	51	71
0	0	0	0	0	0	8	52	52	52	52	52	52	72
0	0	0	0	0	0	9	53	52	52	53	53	52	73
0	0	0	0	0	0	10	54	54	54	54	54	54	74
0	0	0	0	0	0	11	55	54	54	55	55	54	75
0	0	0	0	0	0	12	55	55	55	55	55	55	76
0	0	0	0	0	0	13	56	55	55	56	56	55	77
0	0	0	0	0	0	14	57	57	57	57	57	57	78
0	0	0	0	0	0	15	58	57	57	58	58	57	79
7	7	7	7	7	7	16	59	59	59	59	59	59	80
0	0	0	0	0	0	17	61	59	59	61	61	59	81
0	0	0	0	0	0	18	62	62	62	62	62	62	82
0	0	0	0	0	0	19	64	62	62	64	64	62	83
10	10	10	10	10	10	20	64	64	64	64	64	64	84
0	0	0	0	0	0	21	65	64	64	65	65	64	85
0	0	0	0	0	0	22	66	66	66	66	66	66	86
0	0	0	0	0	0	23	67	66	66	67	67	66	87
13	13	13	13	13	13	24	68	68	68	68	68	68	88
0	0	0	0	0	0	25	68	68	68	68	68	68	89
0	0	0	0	0	0	26	69	69	69	69	69	69	90
0	0	0	0	0	0	27	70	69	69	70	70	69	91
16	16	16	16	16	16	28	71	71	71	71	71	71	92
0	0	0	0	0	0	29	72	71	71	72	72	71	93
0	0	0	0	0	0	30	72	72	72	72	72	72	94
0	0	0	0	0	0	31	73	72	72	73	73	72	95
18	18	18	18	18	18	32	74	74	74	74	74	74	96
0	0	0	0	0	0	33	76	74	74	76	76	74	97
19	19	19	19	19	19	34	78	78	78	78	78	78	98
0	0	0	0	0	0	35	79	78	78	79	79	78	99
21	21	21	21	21	21	36	80	80	80	80	80	80	100
0	0	0	0	0	0	37	81	80	80	81	81	80	101
22	22	22	22	22	22	38	82	82	82	82	82	82	102
0	0	0	0	0	0	39	83	82	82	83	83	82	103
24	24	24	24	24	24	40	83	83	83	83	83	83	104
0	0	0	0	0	0	41	84	83	83	84	84	83	105
26	26	26	26	26	26	42	85	85	85	85	85	85	106
0	0	0	0	0	0	43	86	85	85	86	86	85	107
27	27	27	27	27	27	44	87	87	87	87	87	87	108
0	0	0	0	0	0	45	87	87	87	87	87	87	109
29	29	29	29	29	29	46	88	88	88	88	88	88	110
0	0	0	0	0	0	47	89	88	88	89	89	88	111
31	31	31	31	31	31	48	90	90	90	90	90	90	112
32	31	31	32	32	31	49	92	90	90	92	92	90	113
33	33	33	33	33	33	50	93	93	93	93	93	93	114
34	33	33	34	34	33	51	95	93	93	95	95	93	115
34	34	34	34	34	34	52	96	96	96	96	96	96	116
35	34	34	35	35	34	53	97	96	96	97	97	96	117
36	36	36	36	36	36	54	98	98	98	98	98	98	118
37	36	36	37	37	36	55	98	98	98	98	98	98	119
37	37	37	37	37	37	56	0	0	0	0	0	0	120
38	37	37	38	38	37	57	0	0	0	0	0	0	121
39	39	39	39	39	39	58	0	0	0	0	0	0	122
40	39	39	40	40	39	59	0	0	0	0	0	0	123
41	41	41	41	41	41	60	0	0	0	0	0	0	124
41	41	41	41	41	41	61	0	0	0	0	0	0	125
42	42	42	42	42	42	62	0	0	0	0	0	0	126
43	42	42	43	43	42	63	0	0	0	0	0	0	127

TABLE 3: RECEIVED DIL U-CODE INDICIES

**PATENT**

Although a number of embodiments of the present invention have been presented by way of example, the present invention should not be construed to be limited thereby. Rather, the present invention should be interpreted to encompass any and all variations, permutations, modifications, adaptations, embodiments and derivations which would occur to one skilled in this art, having been taught the present invention by the instant application. Accordingly, the present invention should be construed as being limited only by the following claims.